Lesson 2.2

"Designing Wheelchairs"

Lesson Overview

Students explore the relationship between force, mass, and velocity change by reading about an engineer who designs wheelchairs for different types of athletic competitions. Students learn that wheelchairs built for stability, not speed, have greater mass while wheelchairs designed for speed have less mass. The teacher models the Active Reading approach, which involves annotation strategies for students to practice as they read the article. The purpose of this lesson is to engage students in Active Reading as they gather more information about the relationship between force, mass, and changes in an object's velocity.

Anchor Phenomenon: Rather than stopping and docking at the space station, the asteroid sample-collecting pod moved in the opposite direction.
Investigative Phenomenon: Different wheelchair designs make them better or worse for certain activities.

Students learn:

- Reading actively means thinking about one's own understanding as one reads.
- Expert readers build understanding by asking more focused, deeper questions as they read.
- Wheelchairs built for stability, not speed, have greater mass. This means the wheelchairs change velocity less upon impact with other wheelchairs.
- Wheelchairs built for racing have the lowest possible mass. This way, the wheelchairs can change velocity as much as possible when the rider exerts a force on them.
- Advances in technology influence the progress of science and science has influenced advances in technology.

Lesson at a Glance

ACTIVITY

1

Warm-Up (5 min)
Students activate prior knowledge about what kind of force would be needed to make objects of different mass have the same change in velocity.

WARM-UP

2

Active Reading: "Designing Wheelchairs" (25 min)
Students practice the Active Reading approach while deepening their understanding of the relationship between mass, force, and velocity. The teacher uses this opportunity as an On-the-Fly Assessment of students' ability to engage with scientific texts and ask deeper questions.

READING

3

Discussing Annotations (15 min)
Students address potential confusions about the relationship between mass, force, and velocity through a discussion of the reading. Students' annotations provide an opportunity for an On-the-Fly Assessment of annotation skills, reading comprehension, and content understanding.

STUDENT-TO-STUDENT DISCUSSION

Materials & Preparation

Materials

For the Class

- masking tape*
- Annotation Trackers*

For Each Student

- optional: printed copy of the "Designing Wheelchairs for All Shapes and Sizes" article*
- optional: *Force and Motion* Investigation Notebook, pages 38–40*

Digital Tools

- "Designing Wheelchairs for All Shapes and Sizes" in the Amplify Library

*teacher provided

Preparation

Before the Day of the Lesson

1. **Locate and post your Active Reading Guidelines poster.** If you taught an Amplify Science launch unit (*Microbiome*, *Harnessing Human Energy*, or *Geology on Mars*), you already created this poster. If you do not have it, create one on chart paper, using the image in Digital Resources as a guide.
2. **Prepare for Active Reading lesson.** If this is your first time conducting a lesson in Active Reading, prepare for it by doing the following:
    - **Practice making annotations in the Amplify Library.** Practicing this will prepare you to instruct students on how to navigate in the Amplify Library and how to annotate directly in the article.

VOCABULARY

- cause
- effect
- exert
- force
- mass
- velocity

UNPLUGGED?

Digital Devices Not Required

This lesson can be taught without devices. If students do not have access to devices, print copies of the "Designing Wheelchairs for All Shapes and Sizes" article and Investigation Notebook pages for this lesson (PDFs of both can be found in Digital Resources).

DIGITAL RESOURCES

Designing Wheelchairs for All Shapes and Sizes

Printable article: "Designing Wheelchairs of All Shapes and Sizes"

Annotation Tracker Instructions

Annotation Tracker

Annotation Summary Sheet

- **Preview instructions and rationale for using the Annotation Tracker.** You will need one copy of the Annotation Tracker for each class. Preview the instructions for using the tracker to record student annotations during Active Reading. Read the Annotation Tracker Instructions and view the Example Annotation Trackers in Digital Resources for more information.

3. **Read the article, "Designing Wheelchairs for All Shapes and Sizes", in the Amplify Library.** Familiarize yourself with what students will be reading in Activity 2. A printable PDF of the article is in Digital Resources.
4. **Print a copy of the Annotation Tracker for each class.** A PDF file of the Annotation Tracker can be found in Digital Resources.
5. **Prepare to model Active Reading.** Review Activity 2 and plan how to model the process of Active Reading. Note that you can use the script provided or modify it to reflect your own questions, ideas, and connections about the article. If you choose to model your own thinking in that part of the lesson, consider focusing on similar aspects of the article. In the modeling script provided, we chose to focus on asking deeper questions. This target for modeling was chosen because it is a strategy that is especially important for reading and understanding science texts.
6. **Prepare for On-the-Fly Assessment.** There are two On-the-Fly Assessments included in this lesson. Activity 2 provides an opportunity to informally assess students' ability to engage with scientific texts and to ask deeper questions. In Activity 3, students' annotations provide an additional opportunity for informal assessment. Press the hummingbird icon and select ON-THE-FLY ASSESSMENT for details about what to look for and how you can use the information to maximize learning by all students.

Example Annotation Trackers

Active Reading Guidelines

Force and Motion Investigation Notebook, pages 38–40

Force and Motion Glossary

Force and Motion Multi-Language Glossary

Immediately Before the Lesson

1. **Be sure the Investigation Question is still written on the board.** If not, write, "If the same strength force is exerted on two objects, why might they be affected differently?"
2. **Have on hand the following materials:**
   - Annotation Trackers
   - optional: digital devices
   - optional: printed copies of the "Designing Wheelchairs for All Shapes and Sizes" article
   - optional: *Force and Motion* Investigation Notebooks, pages 38–40

Between-Class Prep

1. **Erase digital annotations.** Erase the digital annotations you made in the Amplify Library before modeling for the next class.

2. **Locate a new Annotation Tracker for your next class.**

At the End of the Day

1. **Print a copy of the Annotation Summary Sheet for each class.** A PDF file of the Annotation Summary Sheet is in Digital Resources.
    - **Use the Annotation Trackers to review students' submitted articles.** If you have time to review students' submitted articles and annotations, continue to fill out each Annotation Tracker to identify questions, alternate conceptions, and exemplary annotations.
    - **Use the Annotation Summary Sheets to analyze students' annotations.** The Annotation Summary Sheet is intended to help you identify trends in student thinking, recurring questions students have about the text, and other issues that you might want to address. Use your Annotation Trackers to fill out the Annotation Summary Sheets.
    - **Collect exemplary annotations and recurring alternate conceptions to share with the class.** Exemplary annotations and recurring alternate conceptions can be shared in the next lesson. Identify examples of student annotations that are thought provoking, exemplify the Active Reading approach, and/or target key science ideas.

Differentiation

Embedded Supports for Diverse Learners

Extended teacher modeling. The Active Reading approach includes many supports that are embedded in each lesson. This approach to reading is based on curiosity, inquiry, and the awareness that students learn more from reading when they are active participants and when they are provided with opportunities to share their own thinking about the text. Thus, extended modeling is a scaffold because it sets the tone for an approach to reading that is positive, inquiry-based, and supports all types of readers. Model the types of thinking that you hope your students will adopt while reading. The modeling suggestions in the instructional guide are intended to serve as a useful guide, but we also encourage you to use this think-aloud technique to model any other aspects of sophisticated reading and deeper thinking that you think will benefit your class.

Student-to-student discussion for making sense of the reading. Student discussion after reading is another valuable scaffold of the Active Reading approach. Students can share their thinking and questions with peers and take advantage of this time, as well as the whole-class sharing time, to work through alternate conceptions or to share insights.

Multimodal learning. Active Reading is one component of a multimodal approach to learning in which students encounter concepts through reading, talking, investigating, and writing. This multimodal approach has been shown to be a highly effective strategy for all students to learn content.

Potential Challenges in This Lesson

Reading focus. This lesson requires that students actively engage with the text, both through reading and through annotation. You may recommend that some students work in pairs as they read "Designing Wheelchairs for All Shapes and Sizes" aloud, annotating their own articles while they read. Another option for providing more support is to form small groups of students who can work together during a first read. You can also have students read with you or with another adult.

Partner discussion after reading. Student-to-student discussion is central to the Active Reading approach, and after reading, students will discuss and share their thinking, questions, and connections. In order for this to work well for both partners, it is important that both students feel safe and comfortable sharing their ideas. You may want to carefully consider which student pairings will promote learning and a feeling of safety and inclusion.

Specific Differentiation Strategies for English Learners

Extended teacher modeling with pairs or small groups. Extended modeling of Active Reading with a small group of English learners can help them surface their questions and confusions about the text within a supportive environment. Before students read, choose a section of "Designing Wheelchairs of All Shapes and Sizes" to read aloud with a small group of English learners and model what to do when you don't understand some part of the text. Think aloud as you model how to notice a break in your understanding and then reread this section slowly. Focus on identifying challenging words or words used in unfamiliar ways and asking questions to clarify your understanding. Encourage students to use these strategies as they read and provide time for them to try them out on their own. After reading, you can provide additional time for the class or the smaller group you met with to share and discuss parts of the text that they found confusing.

Encouraging students to use the *Force and Motion* Glossary. Throughout this unit, you will find additional science resources for supporting English learners. These resources include a glossary, with definitions in Spanish for primary Spanish speakers. At this point, many students may already know about this glossary, since students have been introduced to it either on their digital devices or via the printed version you've provided (or both), but the glossary can be especially helpful during lessons in which students are reading. If you have English learners in your class whose primary language is Spanish, point out this glossary (every lesson includes the digital glossary in Digital Resources), and advise them to use this resource as needed during the lesson.

Specific Differentiation Strategies for Students Who Need More Support

Create a positive environment by setting attainable goals. Establishing expectations for Active Reading and building enthusiasm and excitement around this practice might take time. You may find that many students disengage during independent reading time. These students might feel overwhelmed by the length of the articles or the cognitive load involved in having to read an entire article, record annotations, and summarize sections of text. For this reason, they might resist reading because they feel they cannot be successful. Or, students might make a strong effort to read and annotate, but run out of time before they are able to finish the first few paragraphs of the article. It is important that students who struggle or who are intimidated by reading have a strategy for feeling successful as they read, even if they do not finish the entire text. Suggest the goal of recording at least one question about the text and completing one summary. Offer to help these students with summarizing if writing a summary seems too difficult.

Focus on analyzing visual representations. Another avenue for supporting students is to focus on the visual representations in the text. Many visual representations provide core ideas on their own. For instance, to ensure that students gain experience thinking about how mass affects an object's change in velocity when a force is exerted on it, you may want to ask students who need more support with reading to begin by viewing and annotating the diagram comparing the amount of force needed to stop a more and less massive wheelchair. Students often feel more confident thinking about and commenting on a visual representation than they might feel with a traditional text. In addition, you could ask these students to read the paragraphs that accompany this diagram rather than expecting them to read the entire article. This will allow students the chance to access the main content and add annotations in the same way that their peers are doing.

Specific Differentiation Strategies for Students Who Need More Challenge

Asking deeper questions and making broader connections. Students who need more challenge should be encouraged to push themselves to ask deeper questions and make broader connections while they read. Active Reading is a very sophisticated way to read, and many advanced learners who haven't used this practice before are surprised and pleased to see how much more they get out of reading when they take the time to slow down and interact with the text in this way. You can also ask students who need more challenge to write down the three most important things they learned from the text after reading or to write down what ideas and questions they have about force and mass that weren't addressed in the text.

Standards

Key

Practices Disciplinary Core Ideas Crosscutting Concepts

3-D Statement

Students ask questions and obtain and evaluate information as they read "Designing Wheelchairs," an article about how engineers use ideas about mass, force, and change in velocity to design wheelchairs for different purposes (cause and effect).

Next Generation Science Standards (NGSS)

NGSS Practices

- **Practice 1:** Asking Questions and Defining Problems
- **Practice 8:** Obtaining, Evaluating, and Communicating Information

NGSS Disciplinary Core Ideas

- **PS2.A: Forces and Motion**:
  - The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)
- **PS2.A: Forces and Motion**:
  - All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS- PS2-2)

NGSS Crosscutting Concepts

- Cause and Effect

Common Core State Standards for English Language Arts (CCSS-ELA)

- **CCSS.ELA-LITERACY.RST.6-8.1:** Cite specific textual evidence to support analysis of science and technical texts.
- **CCSS.ELA-LITERACY.RST.6-8.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics
- **CCSS.ELA-LITERACY.WHST.6-8.9:** Draw evidence from informational texts to support analysis, reflection, and research
- **CCSS.ELA-LITERACY.CCRA.SL.1:** Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively
- **CCSS.ELA-LITERACY.CCRA.L.4:** Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized references materials, as appropriate

Common Core State Standards for Mathematics (CCSS-Math)

CCSS-Math Practices

- **CCSS.MATH.PRACTICE.MP1:** Make sense of problems and persevere in solving them.
- **CCSS.MATH.PRACTICE.MP2:** Reason abstractly and quantitatively.

CCSS-Math Content

- **CCSS.MATH.CONTENT.6.RP.2:** Understand the concept of a unit rate a/b associated with a ratio a: b with b ≠ 0 (b not equal to zero), and use rate language in the context of a ratio relationship

- **CCSS.MATH.CONTENT.7.RP.2:** Recognize and represent proportional relationships between quantities.
- **CCSS.MATH.CONTENT.7.RP.2a:** Decide whether two quantities are in a proportional relationship.

1 WARM-UP
Warm-Up

Warm-Up

5 MIN

Students consider what questions they could investigate about the topic of force and motion, and how they might begin their investigation.

Instructional Guide

1. Project Warm-Up. Collapse the instructional guide and project the student screen, or have students turn to page 39 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

Teacher Support

Instructional Suggestion

Going Further: Answering Questions and Testing Hypotheses
During the Warm-Up, some students will likely come up with creative and interesting investigable questions. If you have time you may want to provide students with an opportunity to take their ideas and develop them further by refining their questions and predictions/hypotheses, planning which materials to use, and creating investigations of their own. You could have students work in pairs, small groups, or independently, then share their results with their peers.

Possible Responses

Answers will vary.

2 READING
Active Reading: "Designing Wheelchairs"

Active Reading: "Designing Wheelchairs"

25 MIN

The teacher models Active Reading. Students read an article about how forces affect wheelchairs of different mass with the goal of adding annotations that ask more probing, deeper questions.

Instructional Guide

1. Discuss the Warm-Up. Ask a few students to share ideas they had for investigations.

2. Connect Conducting Investigations to making advances in science and engineering.

Scientists come up with questions to carry out investigations so that they can improve their understanding of different topics they are interested in. Engineers, or people who use science to design things, also ask questions and carry out investigations. They do this to improve their designs. Today, we are going to read about some designs that engineers worked on to help people and improve their lives.

3. Preview the reading. Explain that Dr. Gonzales sent an article that might be helpful with understanding how the same thruster force could have affected this pod so differently, especially if our guess is correct—it had a different-from-usual number of samples on board. Explain that the article is not about space pods, but designing wheelchairs for different types of people and activities, so students will need to apply the information to the pod that moved unexpectedly.

4. Project and introduce "Designing Wheelchairs for All Shapes and Sizes." Project the "Designing Wheelchairs for All Shapes and Sizes" article from the Amplify Library, or project the printed article using a document camera. Point to the introduction, which you will read together, so you can model how you want students to read this science text. Students will then read the rest of the article individually.

5. Model Active Reading. As you model, emphasize the importance of asking deeper questions that will help students understand the relationship between mass, force, and velocity. Use the following script, or model your own thinking.

- **Read the title and first five sentences aloud; think aloud as you connect the title and introductory sentences** (stopping after the sentence that ends with "… the different activities they want to do").
  Say: "I see that the phrase *all shapes and sizes* in the title referred to the wide range of people who use wheelchairs and the different ways they use them."

- **Record your question by highlighting and adding a note.**
  Say: "By highlighting the second sentence with your cursor, a pop-up menu will appear."
  Write: Highlight "Some wheelchairs have motors, and others are operated by hand." Press ADD NOTE and type, "In what other ways are wheelchairs different?"

- **Discuss when to ask deeper questions. Remind students that asking questions is an important strategy that skilled readers use to check their understanding.**
  Say: "Scientists and other skilled readers often ask deep questions when they read something they wonder about, do not quite understand, or something that doesn't quite seem to fit with what they already know."

- **Explain how deeper questions are different from other questions.**
  Say: "Asking deeper questions might mean taking a simple question, such as How? or Why? and adding more focus to it. Since one-word questions don't help me think carefully about what I really want to know, I am going to try and make my question more specific. Deeper questions combine what you already know, what you've already read, and what you are still wondering; together, they make a question that helps you think more carefully about the specific ideas in the article."

- **Model developing an initial question into a deeper question.**
  Say: "I'm going to revise my question so it focuses on the topic of designing wheelchairs for different activities, which is the focus of this article."
  Write: Press EDIT and type: "How are the differences designed to help make wheelchairs better for each activity?"
  Say: "This is a deeper question than it was before because it relates to an important idea in the article—designing wheelchairs for specific activities. Challenge yourself to ask deeper questions as you read further in this article."

6. Project and review Active Reading Guidelines. Collapse the instructional guide and project the student screen, or have students turn to page 40 in their Investigation Notebooks. Point out that these guidelines are also posted in the classroom. Briefly discuss each guideline, emphasizing that you would like students to focus on asking deeper questions.

7. Instruct students to begin reading and annotating. Circulate as students read, using the Annotation Tracker to record annotations that you would like to invite students to share during the class discussion.

8. On-the-Fly Assessment: Asking Deeper Questions. For further suggestions on how to support students as they annotate, press the hummingbird icon and select ON-THE-FLY ASSESSMENT.

Embedded Formative Assessment

On-the-Fly Assessment 4: Asking Deeper Questions

Look for: This reading activity is an opportunity to check on students' ability to ask deeper questions. As with all reading lessons, students should be free to annotate in the unique ways that are helpful to their individual learning and personal style. Look for students to be actively engaged in the reading and annotation process. Students may make a wide range of annotations that reflect their varying levels of science understanding. This variation is fine. You can review annotations, checking for students' ability to ask deeper questions, by asking yourself the following:

- Do the questions go beyond simply asking Why? or How did that work?
- Are the questions specific and related to the text or to classroom experiences? Some examples:
    - How do wheelchairs with different masses function differently?
    - What would happen if you used a light wheelchair to play rugby?
    - How would they design a wheelchair that is both quick and stable?

Now what? This reading experience is intended to give students the space to make a personal connection with the text. However, some students may need support with asking deeper questions as they read. Consider periodically reading an exemplary annotation aloud. Provide positive, encouraging feedback about why this annotation is a good example of Active Reading. You can also offer general prompts to support deeper engagement:

- What questions do you have about this paragraph (illustration or photograph)?
- Were there any words or phrases that were confusing to you?

To promote this strategy of asking deeper questions, you can offer these prompts:

- Was there something in this text that caused you to wonder or have a question? If so, what?
- Is there something confusing about this text that you could explain in a question?

Some students who are more familiar with annotating during reading may stick with superficial questions. If this is the case, you can challenge these students to record more academically minded annotations by selecting and sharing examples that show critical thinking and deeper questions related to science content. If students have written simple questions such as Why? or How?, you can encourage them to extend these questions and articulate richer, more complex questions.

Teacher Support

Rationale

Science Reading: Asking Questions During Reading
Asking questions about the text is a way for students to show a deep engagement with the reading. Questions provide an access point for all levels of readers. Some students will ask questions about the text that will be answered in the next paragraph, others will ask questions that require research, and some will ask questions that scientists in the field are studying. The purpose of this lesson is simply to provide students with support in asking deeper questions so students can begin to show their understanding of the content presented in the text.

3 STUDENT-TO-STUDENT DISCUSSION
Discussing Annotations

Discussing Annotations

15 MIN

Students share their questions and ideas from "Designing Wheelchairs for All Shapes and Sizes."

Instructional Guide

1. Project Discussing Annotations; select annotations to share. Explain that students will review their annotations and choose one or two questions or connections that they find interesting and want to share with a partner. Ask students to consider annotations that ask deeper questions. Have them tag the annotation(s) by pressing EDIT and writing "#share."

Discussing Annotations

#share	Carefully choose an interesting annotation (comment, question, connection, vocabulary word) you'd like to share with your partner and add #share to this annotation.
#discussed	Add #discussed to your annotation if you feel that you and your partner have resolved a question OR if your discussion gave you a deeper understanding about something in the article.
#present	Add #present to your annotation to mark any unresolved questions or ideas you would like to present to the class.

2. Prompt partners to discuss annotations. Circulate as partners discuss, using the Annotation Tracker and listening for questions and connections that you would like to share during the class discussion. Ask students to change the tags of their shared annotations to "#discussed" if they think the partner discussion gave them a deeper understanding or if their questions were answered.

3. Prompt partners to prepare for class discussion. Ask students to choose an interesting or unanswered question that they would like to share. Explain that these can be the same annotations that they already shared if the question is still unresolved. Ask students to tag the annotations they would like to share with the class by pressing EDIT and writing "#present."

4. Facilitate a brief class discussion about annotations. Invite students to share their tagged questions and connections. Encourage students to respond to one another and to look back at the article as they try to answer their peers' questions.

5. Discuss advances in technology and the progress of science and engineering.

This article also helps to make an important point: science influences technology. In this case, the technology is wheelchairs—specifically the specialized wheelchairs scientists and engineers have designed.

What are some ways science affected the design of this technology?
[The science behind forces, objects, and motion was used to design initial wheelchairs, and as each design improved or became more specific, they had to rethink the new materials, etc., using their understanding of science.]

Of course, technology can also affect science. Can you think of an example of how new technology helps scientists make new discoveries?
[Answers will vary: for example, spacecraft allow scientists to make discoveries about outer space.]

6. Conclude the discussion by highlighting exemplary or noteworthy annotations. Refer to your Annotation Tracker and invite students with annotations that you noted to share them with the class. Provide specific, positive feedback as students share, noting when annotations show evidence of Active Reading. When possible focus on the strategy of asking deeper questions.

7. Return to the strategy of asking deeper questions by acknowledging student work. Either by selecting a question in advance or asking for student volunteers, highlight some deeper questions and ask about the thinking process: What kinds of thoughts went into coming up with the question?

8. Reflect on the utility of asking deeper questions while reading. Ask students whether or not they thought this strategy was useful. Acknowledge that asking deeper questions can slow one down and interfere with the flow of reading, but when reading difficult texts, it is often very helpful to employ this strategy.

If students are using devices, ask them to press NEXT to continue.

9. Prompt students to review annotations and submit annotated articles. "Wheelchair Design for All Shapes and Sizes" and each student's annotations should be visible on their digital devices. Have students answer the reflection question on their screens or on page 40 of the notebook, and then submit their articles and annotations by pressing HAND IN.

10. On-the-Fly Assessment: Insight from Student Annotations. For further suggestions about reviewing students' annotations, press the hummingbird icon and select ON-THE-FLY ASSESSMENT.

Embedded Formative Assessment

On-the-Fly Assessment 5: Insight from Student Annotations

Look for: Review submitted student annotations after class. You can use these annotations to assess students' annotation skills, reading comprehension, and content understanding. Use the Annotation Tracker and Annotation Tracker Instructions for guidance.

Now what? See the Annotation Tracker Instructions for suggestions on how to further support students

Teacher Support

Instructional Suggestion

Science Reading: Identifying Exemplary Student Annotations
Identifying examples of student annotations that are thought provoking, exemplify the Active Reading approach, and/or target key science ideas will help you make the most of the class discussion. As students read, circulate and use the Annotation Tracker to identify annotations you would like to discuss. Consider looking for the following types of annotations:

- thought-provoking questions or connections that could enrich the class discussion
- instances where students were able to answer their own questions by reading further or returning to the text
- instances that highlight a student's individual annotation style and illustrate how students can annotate the text in unique ways that are meaningful to them.

Rationale

Science Reading: The Importance of Making Time to Discuss and Share Annotations
Making time to discuss students' annotations can help achieve the following goals in your classroom:

- **Promote a culture of inquiry.** When students can discuss their own connections and pursue answers to their questions collaboratively, they are able to see how feeling confused and challenged by a text is a normal and productive part of science reading.
- **Help students see value in the Active Reading approach and cultivate intrinsic motivation for reading.** Students annotate their articles in unique and creative ways. When students are exposed to many different ways to annotate a text, they can take ownership of the Active Reading process.
- **Provide an opportunity for formative assessment.** Students' thinking, made visible by their annotations and discussions, can help you identify concepts for which students need more support.

Rationale

Pedagogical Goals: Understanding the Nature of Science
One goal set forth by the Next Generation Science Standards (NGSS) is for students to understand the nature of science as a discipline and how scientific knowledge develops over time. The NGSS calls out eight understandings about the nature of science that are woven throughout the Amplify Science curriculum. This unit gives students an opportunity to experience the understanding that Science is a Human Endeavor. Specifically, the article "Designing Wheelchairs" illustrates the idea that advances in science has influenced advances in technology. The following discussion emphasizes this idea and also highlights the idea that technology affects scientific discovery.

Lesson 2.3

Explaining Mass, Force, and Velocity

Lesson Overview

Students deepen and demonstrate their understanding of the relationship between mass, force, and velocity. To begin, students use the Sim to test how equal forces exerted on objects of different mass affect their motion. Inspired by the need to apply their ideas to a new task—designing a wheelchair that would perform well for basketball players—students return to "Designing Wheelchairs for All Shapes and Sizes" to see how forces exerted on wheelchairs of different mass affect their velocities. A Modeling Tool activity helps students segue from wheelchairs to space pods, specifically to ideas about this pod's mass and the two unit claims. They create visual models for each claim that offer tentative answers to the Chapter 2 Question. For homework, students write scientific explanations for both claims: how a change in mass (the number of asteroid samples) could have caused the pod to move away from the space station, either before it got there or after a collision. The purpose of this lesson is for students to deepen their understanding of the relationship between mass, force exerted, and velocity change so they can apply this understanding and explain what could have happened to the pod.

Anchor Phenomenon: Rather than stopping and docking at the space station, the asteroid sample-collecting pod moved in the opposite direction.
Design Problem: Design a wheelchair for basketball players.

Students learn:

- If the same strength force is exerted on two objects but the objects have different masses, the object with less mass will have a greater change in velocity.

Lesson at a Glance

ACTIVITY

1 **Warm-Up** (5 min)
Students use the Simulation to observe how forces of equal strength affect the velocities of objects with different masses.
WARM-UP

2 **Revisiting "Designing Wheelchairs"** (20 min)
Students reflect on and apply ideas about how mass affects force and velocity as they reread an article from Lesson 2.2.
READING

3 **Modeling the Effects of Different Masses** (20 min)
Students demonstrate their knowledge of how mass affects force and velocity as they model claims about what could have happened to the pod. This offers an On-the-Fly Assessment opportunity to assess how students engage in the practice of developing and using models as well as the opportunity to assess students' understanding of the relationship between force, mass, and change in velocity.
MODELING TOOL

4 **Homework**
Students apply their understanding of mass, velocity, and force to explain two possible claims about what could have happened to the ACM pod.
HOMEWORK

Materials & Preparation

Materials

For the Classroom Wall

- key concept: *If the same strength force is exerted on two objects but the objects have different masses, the object with less mass will have a greater change in velocity.*

For the Class

- masking tape*

For Each Student

- optional: *Force and Motion* Investigation Notebook, pages 41–46*

Digital Tools

- *Force and Motion* Simulation
- "Designing Wheelchairs for All Shapes and Sizes" in the Amplify Library
- *Force and Motion* Modeling Tool activities: **Claim 1, Chapter 2** and **Claim 2, Chapter 2**

*teacher provided

Preparation

Before the Day of the Lesson

1. **Gather today's classroom wall materials from your *Force and Motion* kit.**
   - key concept: *If the same strength force is exerted on two objects but the objects have different masses, the object with less mass will have a greater change in velocity.*

VOCABULARY

- cause
- effect
- exert
- force
- infer
- mass
- velocity

UNPLUGGED?

Digital Devices Required

It is highly recommended that students have access to digital devices for this lesson. If students do not have individual devices, print copies of the Investigation Notebook pages for this lesson (PDFs can be found in Digital Resources) and have students complete the Modeling Tool activity in pairs.

If students do not have access to Amplify Science at home, provide them with a copy of page 46 from the Investigation Notebook.

DIGITAL RESOURCES

Designing Wheelchairs for All Shapes and Sizes

2. **Select student annotations.** Use your completed Annotation Trackers and Annotation Summary Sheets from Lesson 2.2 to identify one or two exemplary annotations to share. They can be general examples or specific to particular class sections. You may also wish to identify any alternate conceptions, revealed in students' annotations, that you would like to discuss.

3. **Familiarize yourself with the *Force and Motion* Simulation activity in Activity 1 of this lesson.** For more information about the Sim, see Apps in This Unit under Teacher References at the unit level. For more information on what to expect from students, see the Possible Responses tab in Activity 1.

Printable article: "Designing Wheelchairs for All Shapes and Sizes"

Force and Motion Investigation Notebook, pages 41–46

Force and Motion Glossary

Force and Motion Multi-Language Glossary

4. **Familiarize yourself with the *Force and Motion* Modeling Tool activities: Claim 1, Chapter 2 and Claim 2, Chapter 2 in Activity 3 of this lesson.** For more information about the Modeling Tool, see Apps in This Unit under Teacher References at the unit level. For more information on what to expect from students, see the Possible Responses tab in Activity 3.

5. **Prepare for On-the-Fly Assessment.** Included in Activity 3 of this lesson is an opportunity to informally assess student understanding of the idea that when the same strength force is exerted on objects of different mass, there will be a greater change in the velocity of the less massive object. This assessment also provides an opportunity to assess the science practice of developing and using models. Press the hummingbird icon and select ON-THE-FLY ASSESSMENT for details about what to look for and how you can use the information to maximize learning by all students.

Immediately Before the Lesson

1. **Be sure the Investigation Question is still on the board.** Write, "If the same strength force is exerted on two objects, why might they be affected differently?"

2. **Have on hand the following materials:**
   - digital devices
   - optional: *Force and Motion* Investigation Notebooks, pages 41–46

Between-Class Prep

1. **Have annotations that you will share ready for the next class.**

At the End of the Day

1. **Post the key concept in the designated area of your classroom wall.**
   - *If the same strength force is exerted on two objects but the objects have different masses, the object with less mass will have a greater change in velocity.*

2. **As part of the On-the-Fly Assessment, review students' explanations for the models they submitted in Activity 3.**

Differentiation

Embedded Supports for Diverse Learners

Multiple modalities with the same topic. In this lesson, students engage with concepts about mass, force and velocity by reading a text, observing the *Force and Motion* Simulation, and demonstrating their ideas in the Modeling Tool. Employing multiple modalities with the same topic gives students more chances to make sense of the ideas and makes concepts accessible to more types of learners.

Discussion routine after reading. Student discussion after reading is another valuable scaffold of this approach. Students can share their thinking and questions with peers and take advantage of this time, as well as the whole-class sharing time, to work through alternate conceptions or to share insights.

Potential Challenges in This Lesson

Reading focus. Reading science texts is challenging. It may be difficult for some students to extract the information they are asked to extract from the article. Students who struggle with reading in general may struggle with the reading in this lesson.

Specific Differentiation Strategies for English Learners

Promoting inclusion in discussions. Participating in discussions is critical for English learners to develop critical science knowledge and the language of science. Some English learners may be hesitant to contribute to class or small-group discussions because they lack experience or confidence in participating in small or large group discussions. Extended academic discourse that is equitable (that is, all students have an opportunity to engage) is critical for developing both language and content knowledge. Support students by employing strategies such as partnering ELs with supportive language partners and allowing for a 6-8 second wait time for student responses.

Extra discussion time after reading. Some English learners would benefit from having more time to discuss the article after rereading. To accompany the discussion, you might record students’ thinking on the board as they discuss the topic. Extending the discussion time and supporting students' thinking by giving them time to listen to each other and to record their thinking is an important way to support more students’ understanding of these complex ideas.

Additional sentence starters. English learners may benefit from the support of sentence starters in order to participate more fully in the the Sim activities and partner discussions. You could write the following prompts on the board or distribute paper copies to students who would benefit from having them.

- I notice . . .
- I observe . . .

- I think this is ____, and my evidence is ____.

Specific Differentiation Strategies for Students Who Need More Support

Developing supportive partnerships. Creating positive and supportive student partnerships is a crucial first step in developing a classroom culture where students feel confident and comfortable sharing their thinking. This unit provides many opportunities for student learning to occur through paired or small-group discussion. Creating good working partnerships will be an essential component to the success of these types of lessons. You may want to offer support for students who are less comfortable speaking in class by providing the following prompts as scaffolds and by encouraging students to use them as needed:

- I notice/observe . . .
- I think this is important because . . .
- I wonder . . .

Specific Differentiation Strategies for Students Who Need More Challenge

Provide independent research opportunities. For students who need more challenge, ask them to do independent online research to investigate how mass relates to certain sports. Here are a few possible topics:

- Why people with more massive or less massive body types may be more successful playing certain positions in football.
- Why people with more massive or less massive body types may be assigned to base or flyer positions in cheerleading.
- Why extra mass may be added to the saddle pad of a horse in Thoroughbred racing.
- Why competitors are separated into weight classes in sports like boxing, wrestling, and martial arts.

Standards

Key
Practices Disciplinary Core Ideas Crosscutting Concepts

3-D Statement

Students construct visual models showing how a change in the pod's mass could affect its change in velocity from a given force (cause and effect).

Next Generation Science Standards (NGSS)

NGSS Practices

- **Practice 2:** Developing and Using Models
- **Practice 6:** Constructing Explanations and Designing Solutions
- **Practice 8:** Obtaining, Evaluating, and Communicating Information

NGSS Disciplinary Core Ideas

- **PS2.A: Forces and Motion**:
    - The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)
- **PS2.A: Forces and Motion**:
    - All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS- PS2-2)

NGSS Crosscutting Concepts

- Cause and Effect
- Scale, Proportion, and Quantity

Common Core State Standards for English Language Arts (CCSS-ELA)

- **CCSS.ELA-LITERACY.RST.6-8.1:** Cite specific textual evidence to support analysis of science and technical texts.
- **CCSS.ELA-LITERACY.RST.6-8.7:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table)
- **CCSS.ELA-LITERACY.RST.6-8.9:** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic
- **CCSS.ELA-LITERACY.WHST.6-8.1.B:** Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources
- **CCSS.ELA-LITERACY.WHST.6-8.2:** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes
- **CCSS.ELA-LITERACY.WHST.6-8.9:** Draw evidence from informational texts to support analysis, reflection, and research

- **CCSS.ELA-LITERACY.CCRA.SL.1:** Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively

Common Core State Standards for Mathematics (CCSS-Math)

CCSS-Math Practices

- **CCSS.MATH.PRACTICE.MP1:** Make sense of problems and persevere in solving them.
- **CCSS.MATH.PRACTICE.MP2:** Reason abstractly and quantitatively.
- **CCSS.MATH.PRACTICE.MP4:** Model with mathematics.
- **CCSS.MATH.PRACTICE.MP5:** Use appropriate tools strategically.
- **CCSS.MATH.PRACTICE.MP6:** Attend to precision.

CCSS-Math Content

- **CCSS.MATH.CONTENT.6.RP.2:** Understand the concept of a unit rate a/b associated with a ratio a: b with b ≠ 0 (b not equal to zero), and use rate language in the context of a ratio relationship
- **CCSS.MATH.CONTENT.6.RP.3:** Use ratio and rate reasoning to solve real-world and mathematical problems.
- **CCSS.MATH.CONTENT.6.NS.5:** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation
- **CCSS.MATH.CONTENT.7.RP.2:** Recognize and represent proportional relationships between quantities.

1 WARM-UP
Warm-Up

Warm-Up

5 MIN

Students use the Simulation to test how forces of equal strength affect the velocity of objects with different masses.

Instructional Guide

1. Project Warm-Up; students work independently. Collapse the instructional guide and project the student screen, or have students turn to page 42 in their Investigation Notebooks. Allow a few minutes for students to individually respond to the Warm-Up.

2. Briefly discuss the Warm-Up. Invite several students to share their ideas. Students should note that the less massive object had a greater change in velocity than the more massive object when the same strength force was exerted on both.

3. Remind students of the Investigation Question. As needed, refer to the board to review the question. Explain that students will continue to respond to this question in today's lesson.

Teacher Support

Instructional Suggestion

Providing Additional Support: Extended Discussion Time
Some students would benefit from having more time to discuss their observations in the Sim. Consider having students engage in student-to-student discussion after they observe the results of their Sim tests. Have students share with their partner which object had a greater change in velocity and why they think they observed those results. Then, lead a class discussion where students share their ideas. Extending the discussion time and supporting student thinking by giving them time to listen to one another is an important way to support more students' understanding of these complex ideas.

Possible Responses

What students should do and notice in the Sim:

Student predictions will vary, but these are the correct predictions:

1. If your goal is to make these objects slow down, in which direction should you apply a force? left
2. Object B is more massive than Object A. If you apply the same strength force (4 clicks) to both objects, which object will have a greater change in velocity? Object A

Students should notice that when they exert the same strength force on the object with a mass of 0.5 and the object with a mass of 4, the less massive object will have a greater change in velocity than the more massive object.

2 READING
Revisiting "Designing Wheelchairs"

Revisiting "Designing Wheelchairs"

20 MIN

Students apply ideas about how mass affects force and velocity as they reread an article to help them decide how to design a wheelchair for basketball.

Instructional Guide

1. Introduce the purpose for revisiting the article. Explain that students will deepen their understanding of the relationship between mass, force, and change in velocity by returning to the article they read in the last lesson. They will apply what they learned from the article to a new purpose—thinking about designing a wheelchair optimized for playing basketball.

2. Review the idea behind a second read. Remind students that sophisticated readers often read things multiple times to better understand ideas and difficult concepts presented in the text and accompanying diagrams.

3. Review exemplary annotations from Lesson 2.2. From the analysis you did with the Annotation Tracker, share exemplary annotations that demonstrate thoughtfulness or creativity. You may also want to review and discuss any alternate conceptions that were revealed in students' annotations.

4. Review the reading prompt and directions. Collapse the instructional guide and project the student screen, or have students turn to page 43 in their Investigation Notebooks. Have a student read the prompt.

5. Briefly discuss how players need to move in basketball. Elicit student ideas about what happens in basketball and about the different ways that players need to move in order to participate in the sport. Make sure students know that players start and stop quickly, need to move fast, and sometimes run into each other.

What do players need to do in basketball?
How do they move?
Is it fast or slow?
Do players bump into each other?
Do they stop and start?

Keep in mind all the ways that basketball players need to move when you are thinking about how to design a wheelchair that could be used for this sport.

6. Direct students to reread a section of the article. Provide about 10 minutes for students to read paragraphs 3, 4, and 5, circulating to assist as needed. Remind students to highlight important sentences or phrases that will help them to answer the questions.

7. Prompt students to discuss their ideas and annotations. After students have had time to reread the paragraphs, prompt them to discuss their ideas. They do not have to agree on the design, but they should be able to point to ideas from the text that support their ideas.

8. Have students answer the questions and explain their design ideas.

9. Have volunteers share their ideas. Depending on which idea they thought was more important—stability or the ability to move quickly—students may have made the wheelchair heavy, medium, or light. All these ideas are appropriate, so prompt them to support their choices with ideas from the text about how mass affects force and velocity.

10. Summarize student ideas and discuss proportional relationships. Point out that whether they decided to make the wheelchair more or less massive, they supported their ideas by pointing out that there will be a greater change in velocity when the same force is applied to a less massive object than when it is applied to a more massive object. Explain mass and velocity change have a proportional relationship.

Mass and velocity change are proportional to each other. As one changes, so does the other. In this case, if the mass is less, the velocity change will be greater. This relationship will help you infer the mass of the pod in each claim based on the force exerted on the pod and the velocity change in each claim.

11. Project key concept. Read (or have a student read) the key concept aloud.

Key Concept

If the same strength force is exerted on two objects, but the objects have different masses, the object with less mass will have a greater change in velocity.

Teacher Support

Rationale

Science Reading: Rereading Texts for a Specific Purpose
Rereading is an important method for obtaining information from texts and supporting comprehension. Setting the expectation that students will read texts more than once helps them learn to read closely and to develop an attitude of persistence when they read. Students have already read this article once to understand its overall content and to surface questions and initial ideas. When students reread a section of the article in this lesson, it is for a specific purpose: getting evidence about how mass should be considered when designing wheelchairs for basketball players. As you can, highlight the different purposes for reading a first and second time, and help students develop the expectation that they need to read science texts multiple times in order to build their understanding.

Possible Responses

1. Which wheelchair would be more difficult to stop? a. more massive wheelchair
2. If the same force were exerted on both wheelchairs, which chair would go faster? b. less massive wheelchair
3. How would you design a wheelchair for wheelchair-using basketball players? Would you make it more or less massive? Explain how the text supports your choice. Answers will vary, but should be similar to one of the following:

- I'd make it **very heavy** because it needs to not tip over when the player stops and starts a lot. The text said that heavier objects are more stable because they are harder to stop.

- I'd make it **lightweight** so that it doesn't take much force to stop it or start it. The player needs to stop and start quickly. The text said that lighter objects require less force or effort to change their velocity. So a lighter wheelchair would take less force from the player to get it started or to stop it.
- I'd make it **medium weight**. That way it is somewhat stable when stopping but is also not too hard to start. The text said that heavier objects are more stable because they are harder to stop. The text also said that lighter objects require less force or effort to change their velocity. So a medium weight wheelchair wouldn't take too much force from the player to get it started or to stop it.

3 MODELING TOOL
Modeling the Effects of Different Masses

Modeling the Effects of Different Masses

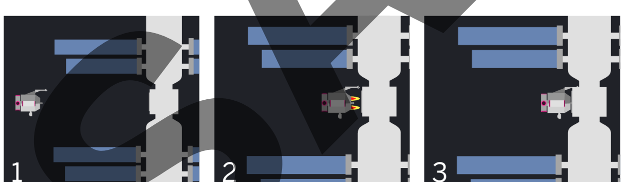
20 MIN

Students model their ideas about how a more and less massive pod's motion would be affected by the same strength of force.

Instructional Guide

1. Project Asteroid Collection Missions. Remind students that the thrusters on this pod exerted the same strength of force as pods on other missions. Review what was expected: with the same force, the pod should slow down, and then stop to dock at the space station. Instead, when the signal was restored, we found this pod moving in the opposite direction.

Asteroid Collection Missions



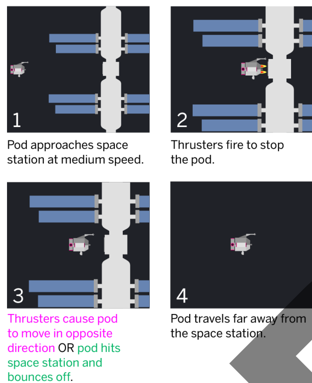
1: Pod approaches space station at medium speed.
2: Thrusters fire to stop the pod.
3: Docking: pod connects to space station.

2. Project and review claims. Remind students that they want to explain what happened to the pod during the time that the signal went out. These two claims offer possible answers to why this pod moved differently after the thrusters were fired. As needed, read the claims aloud and review the storyboards.

Normally, when the thrusters fire, the pod will stop, but this mission was different.

Claim 1: The thrusters caused the pod to move in the opposite direction.

Claim 2: The thrusters only slowed the pod, it didn't stop; the pod hit the space station, which made it bounce and move in the opposite direction.



3. Remind students that this pod's mass is still a question.

The space agency is still determining if the pod had more or fewer samples than normal. Since we know that the same strength of force affected this pod differently, something must have been different about its mass.

4. Project the Pod Force and Mass Questions for a partner discussion. Invite students to turn and talk with a partner about the question next to each claim. Circulate and listen in on student conversations. [Students should respond that for Claim 1, the same strength thruster force on a less massive pod would cause the pod to have a greater change in velocity so it would move in the opposite direction. For Claim 2, students should indicate that the same strength of force on a more massive pod would cause the pod to have a smaller change in velocity so it would slow down, but not stop.]

Normally, when the thrusters fire, the pod will stop, but this mission was different.

Claim 1: The thrusters caused the pod to move in the opposite direction.	*Thruster force: same on all pods* *How could a difference in mass cause this pod to move in the opposite direction?*
Claim 2: The thrusters only slowed the pod, it didn't stop; the pod hit the space station, which made it bounce and move in the opposite direction.	*Thruster force: same on all pods* *How could a difference in mass cause this pod to only slow down—not stop—when the thrusters fired?*

Point out that students inferred that the pod's mass would explain why the same strength of force from the thrusters caused the particular velocity change described in each claim.

5. Explain the modeling activity and introduce the homework. Students will model the inferences they made for each claim and show how the pod moving away from the space station could be related to its mass. They should think about the questions they just discussed as they create their models. As homework, they will use their models to write an explanation about each claim for Dr. Gonzales.

6. Project the Modeling Tool activity: Claim 1, Chapter 2 and show students how to model different mass objects. Remind students that the top row of the Modeling Tool shows what usually happens during asteroid collection missions. Highlight that normally the pod has a medium mass, which is represented by a medium-sized circle. Explain that the Warm-Up test in the Sim was similar to this— the same strength of force was applied to objects of different mass. Point out the circles and inform students the largest circle represents a more massive object and a smallest circle represents a less massive object.

7. Explain submitting first model and continuing to second model. Remind students to press HAND IN so they can see the screenshot of the first model, if they are using digital devices. After that, students will need to press NEXT or review the instructions on page 45 in their Investigation Notebooks to continue to the second model. If students are sharing devices, direct them to switch "drivers" so each partner completes one of the models.

8. Have students complete their models. Circulate and provide assistance as needed. Encourage students to add annotations to their models that explain their thinking.

9. Prompt students to complete the second model. Continue to circulate and provide assistance as needed.

10. Invite students to share their models with a partner or with another pair of students. Encourage students to discuss how they modeled what they inferred about the pod's mass for each claim. Prompt students to discuss the cause-and-effect relationships in their models.

How did you show the effect of the thruster force on the velocity of the pod when it was **more** massive?
How did you show the effect of the thruster force on the velocity of the pod when it was **less** massive?

11. Conclude the lesson by returning to the Investigation Question. Refer to the question on the board and invite students to respond. Encourage students to explain how their Modeling Tool diagrams present an answer to this question.

12. Point out the homework. If students do not have access to Amplify Science at home, provide them with a copy of page 46 from the Investigation Notebook. Explain to students they will write to Dr. Gonzales to explain how different masses (more or fewer asteroid samples) could cause the pod to move in the opposite direction. Encourage students to begin their homework if time allows.

13. On-the-Fly Assessment: Modeling How Mass Affects Motion Changes. Reviewing students' submitted models after class provides an opportunity for formative assessment. For suggestions on how to support students in the practice of developing and using models and their understanding of the relationship between force, mass, and change in velocity, press the hummingbird icon and select ON-THE-FLY ASSESSMENT.

Embedded Formative Assessment

On-the-Fly Assessment 6: Modeling How Mass Affects Motion Changes

Look for: This modeling activity is an opportunity to assess individual student understanding of how an object's mass affects its change in motion from a given force (Level 2 of the Progress Build). For Claim 1, look for models showing that an object (like the pod) would need to have less mass to have a greater change in velocity (move in the opposite direction rather than stop) from the same strength force. Students can demonstrate their understanding of this idea by using the small mass ball in their models. For Claim 2, look for models showing that an object would need to have more mass to have a smaller change in velocity (slow down rather than stop) from the same strength force. Students can demonstrate their understanding of this idea by using the more massive ball in their models. This demonstrates student understanding of the key concept: *If the same strength force is exerted on two objects but the objects have different masses, the object with less mass will have a greater change in velocity.* There might be some variation in the length of the velocity tails that students use to show the reverse motion of the small mass object; as long as the tails are shown to the right of the object (indicating leftward motion), students are demonstrating an understanding of the key concept.

You can also use student models to formatively assess student facility with the practice of developing and using models. Can students successfully represent their understanding of the pod and space station using balls of different masses? Can they consistently use velocity tails as visual representations of an object's speed and direction? Are they able to use the force arrows to represent forces, even though forces are not visible in real-life interactions?

Now what? If students' models do not show an accurate understanding of this key concept, you may want to carefully read students' responses to the homework prompt in order to determine whether students are having difficulty understanding the content or if they are struggling to express their ideas visually with the Modeling Tool. If students are struggling with the content, be prepared to assign them to the Purple or Blue groups in Lesson 2.5 so they can review these concepts. You may also want to offer additional support by extending the review of the key concepts and working with small groups of students as they complete the differentiated activities during Lesson 2.5.

If students are struggling to develop visual models, consider encouraging students to write out their ideas prior to creating visual models. You may also want to convene a small group to review the symbols in the Modeling Tool so students are better prepared for the modeling activities in Chapter 3.

Teacher Support

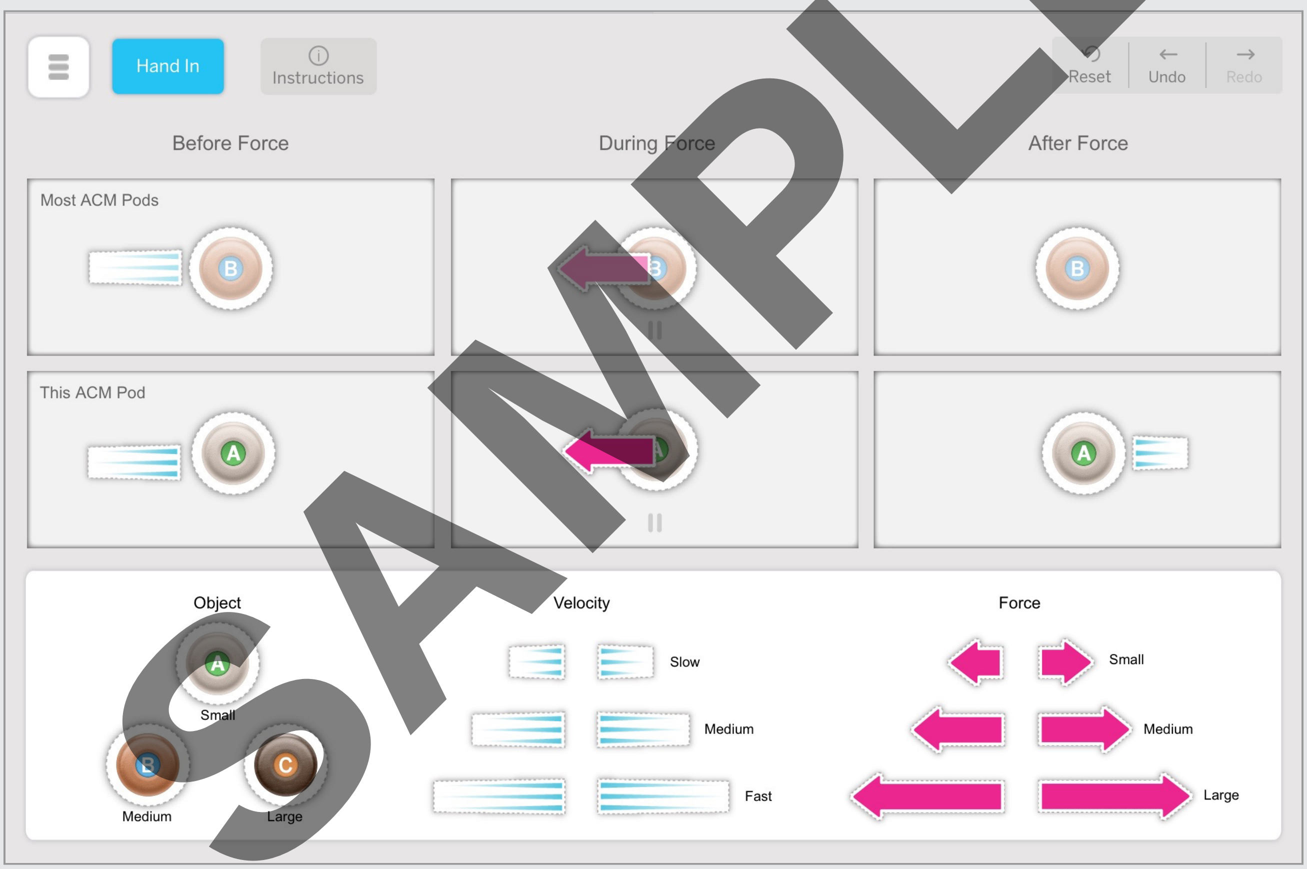
Instructional Suggestion

Crosscutting Concepts: Making Connections Across Science Topics
Students can use the focal crosscutting concept in the *Force and Motion* unit to make connections across science topics. Ask students to think of another topic or content area (in this grade, or in a previous grade) in which they used the crosscutting concept of Cause and Effect, such as the *Ocean, Atmosphere, and Climate* unit. Pose questions like these to students:

- When we were studying what determines a location's climate, what kinds of causes and effects were we analyzing? How are those similar and different to the causes and effects we are analyzing now? [Example: In the *Ocean, Atmosphere, and Climate* unit, we looked at the effect of a location's latitude on its air temperature. In this unit, we are looking at the effect of forces and an object's mass on its change in velocity.]

Possible Responses

Claim 1: One possible proficient model is shown.



Claim 2: One possible proficient model is shown.


Hand In
Instructions
Reset
Undo
Redo
Before Force
During Force
After Force
Most ACM Pods
This ACM Pod
Object
Small
Medium
Large
Velocity
Slow
Medium
Fast
Force
Small
Medium
Large

4 HOMEWORK
Homework

Homework

Students explain how it would have been possible for a pod with a different-from-usual mass to move in the ways described by the two claims.

Instructional Guide

1. If needed, make additional time to explain the homework. If students do not have access to Amplify Science at home, provide them with a copy of page 46 from the Investigation Notebook.

Possible Responses

Claim 1: Firing the thrusters would have caused the pod to move in the opposite direction if . . .
Firing the thrusters would have caused the pod to move in the opposite direction if the pod had been less massive than normal. The same strength force exerted on a less massive pod would cause a greater change in velocity. It would have not only stopped the pod, but also caused it to move in the opposite direction.

Claim 2: Firing the thrusters only slowed the pod, it didn't stop; the pod hit the space station, which made it bounce and move in the opposite direction. This would happen if . . .
the mass of the pod was greater than normal. The same strength force on a more massive pod would have not been enough to stop it. A more massive pod would continue to move forward until it crashed into the space station, and then it would bounce and begin to move away from the station.